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Issue 26

Designing sustainable city communities

BRE

Dozens of innovative and often ingenious designs from round the world were submitted to a competition organised to promote sustainable and successful city neighbourhoods.

The competition was organised by INREB, a Faraday Partnership supported by the UK government. Launched in 2001, INREB harnesses the expertise of BRE, the UK's leading Research and Technology Organisation in the built environment and four world-class academic research groups at the UK universities of De Montfort, Loughborough, Nottingham and Ulster.

Well over 100 entrants from 21 countries took part in this demanding design ideas competition. They were asked to design vibrant, successful neighbourhoods for an area of Manchester (in the north west of England), which would have reduced reliance on fossil fuels and improved energy efficiency, and would address the issues of excessive car use, growing food locally and limiting waste.

This was a challenging brief, but one firmly set in the demands of today. The competition was launched to explore how the radical agenda set out in the UK Government's Energy White Paper, 'Our energy future – creating a low carbon economy' could be applied to a mixed-use urban scheme.

Organised by INREB Faraday Partnership in collaboration with over twenty different international organisations including URBED (The Urban & Economic Development Group) and CIS (Co-operative Insurance Society), the competition forms part of a programme of works designed to help the construction industry respond to the challenge of climate change.

Ideas were invited for a 2.2 hectare brownfield site on the edge of Manchester's city centre, within walking distance of central amenities and with good transport links. The competition was open to two categories – multi-disciplinary teams of built environment professionals (such as planners, urban designers, architects and engineers) and students of relevant degree courses such as architecture and engineering.

The results of the competition, which offered about € 20,500 in prize money, were announced in February 2004. The jury panel, which included architects, engineers, energy consultants and client representatives, was very encouraged by the response. Lead assessor and Director of INREB, Paul Evans of BRE said, 'The brief was extremely challenging, but the winning scheme managed to successfully balance the requirements of a good energy strategy with good urban design and sustainable urban living'.

The winning designs will be displayed in a touring exhibition in May/June 2004, with a supporting series of seminars, and were exhibited at resource04 (a major event on renewable energy held at BRE on 7-10 June).

For further information on the competition (including the prizewinners) or on any other INREB activities, visit **www.inreb.org**

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Innovation: Earthquake loads on masonry structures

After four years of research and experiments at the CSTB, a first Technical Assessment was issued in September 2002 for a masonry process using clay bricks with unfilled vertical joints for construction in seismic zones.

Seismic construction rules suggest that masonry structures made of small elements require a vertical mortar joint between concrete blocks, clay bricks or cellular concrete blocks. This joint is additional to the horizontal mortar layer used traditionally.

This requirement increases the cost of labour for masonry by about 30% and is considered to be economically difficult to achieve for the construction of this type of structure.

The first Technical Assessment (AT) that allows this requirement to be waived (under some conditions) was made possible by research carried out over several years on the behaviour of masonry using small elements, under earthquake loads. Experiments were carried out to test almost all types of masonry used in France.

The results of tests on brick masonry show that the presence of an infill in the vertical joints makes the walls monolithic to a certain extent and enables the transmission of forces to foundations through an inclined compression strut along the diagonal of the panels.

For walls without any vertical joints, forces are transmitted to foundations through a network of short struts parallel to each other, at an inclination along the diagonal of the half-bricks, thus preventing forces from being transmitted through joints that are left dry. However, a minimum panel length is necessary to mobilize these short struts.

A simplified model of the compression strut was proposed in order to predict the ultimate strength of walls based on compression test results of products in the horizontal and vertical directions, taking account of the type of vertical jointing and the type of bricks.

For example, with this model, it has been demonstrated that the minimum wall length necessary to develop the lateral resistance of a floor height panel made of 50 cm long clay bricks constructed with dry joints is 3.60 m.

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A tailor made test bench for research in partnership

A test bench, designed and made by CSTB for the study, was used to apply forces to masonry walls that are similar to actual seismic conditions. A mobile jack placed at the top of the wall applies an alternating force in the plane of the wall in sets of ten 1 Hertz cycles, while another fixed load is applied perpendicular to the plane of the panel. Comparative tests were carried out with and without vertical joints. The measured horizontal displacements of the panel (between 1 and 15 mm) correspond to a jack thrust of between 10 and 50 tonnes.

The CTTB (Centre Technique des Tuiles et Briques - Technical Center for Roof Tiles and Bricks) participated in this research for baked clay bricks, with the CERIB (Centre d'Etudes et de Recherches de l'Industrie du Béton - Industrial Technical Centre for the French precast concrete industry) for concrete blocks, and SFBC (Syndicat Français du Béton Cellulaire - French Cellular Concrete Association) for aerated autoclaved concrete.

CSTB seismic test bench

The Micro-XRF – A New Techniqu Analysis of Building Materials

X-ray fluorescence analysis (XRF) is a widely used tool for the analysis of the chemical composition of inorganic materials. It is particularly suitable for the analysis of building materials due to its speed, simplicity and easy sample preparation. This method has now been expanded by a technique called micro-X-ray fluorescence analysis (micro-XRF). Micro-XRF is not only capable of performing qualitative and quantitative chemical analysis but can also determine the elemental composition in any position on a sample material. A big advantage is the opportunity to use not only powdered but also solid samples for analysis.

Essentially a micro-XRF system consists of the same parts as a standard energy dispersive XRF system. The x-ray beam is generated by an x-ray tube and the fluorescent radiation of the sample is detected by a conventional energy dispersive detector (EDX). The instrument can be equipped with different x-ray tubes depending on the analytical task. A rhodium tube is the best choice if light elements down to sodium and heavy elements need to be detected simultaneously. A system of glass capillaries guide and focus the x-ray beam from the x-ray tube to the sample. Since the capillary optics allows focus change, the spot size of the beam on the material surface can be varied from 30 μm to a maximum of 300 μm. This spot size range is ideal for acquiring chemical information of fairly small features of a solid sample as well as getting a cross chemical composition of a certain material, eg a powder.

Quantitative analysis is possible but within the well known limitations of energy dispersive detector systems. Quantitative measurements can be performed without standards and by using standard calibration. Depending on the type of x-ray tube, light elements might be detected with less accuracy than heavy elements. With a rhodium type tube, for instance, light elements from calcium down to aluminum can be detected in quantities of 0.05 mass-%. Sodium, however, is detectable in quantities not below 0.5 mass-% under ideal measuring conditions.

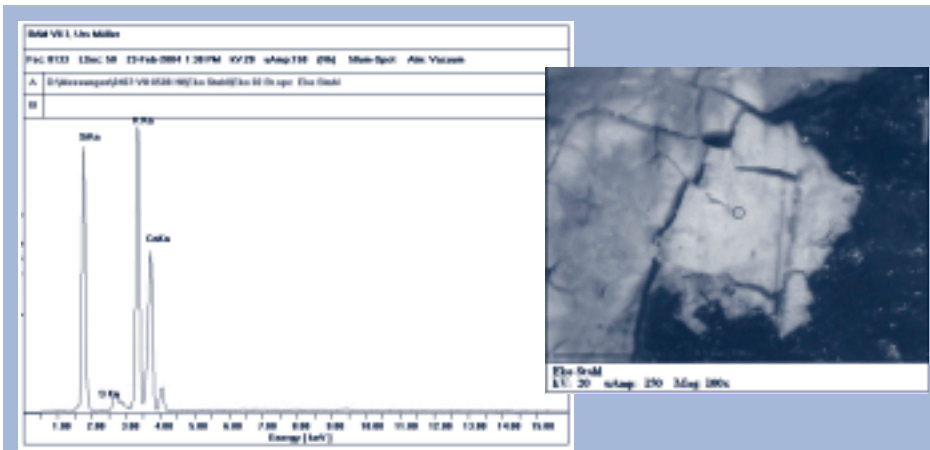

Figure 1. Result of a spot analysis in an area where alkali silica reaction (ASR) occurred. The upper image illustrates the location of the analysis, the lower one the result spectra with the detected elements typical for an alkali gel

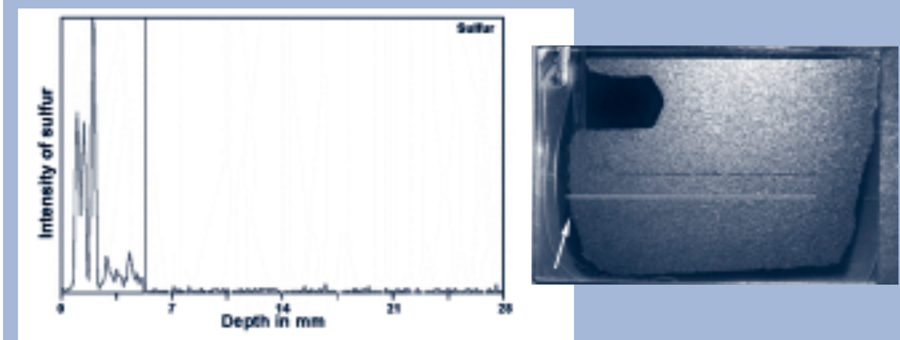

Figure 2. Line scan of a drill core extracted from a sandstone wall. The sandstone was affected by gypsum crystallization (the original surface of the sandstone is indicated by an arrow). Figure 3 shows, that the sulfate (represented by sulfur) penetrated only 5 mm into the sandstone.

The micro-XRF has a large motor driven sample stage, which can be moved in all three directions. The distance of movement is in the range of 100 x 100 x 100 mm^3. Because of the large chamber, samples up to 120 mm in size can be placed on the stage. The detector system consists of a semiconductor crystal and can analyze all excited elements simultaneously. The sample movement and the point of analysis can be monitored by two digital cameras with 10x or 100x magnification. Therefore for each analyzed spot the area of analysis can also be documented (Figure 1). Generally the analysis is performed in vacuum. But volatile substances can be analyzed also in air entailing a lower detection limit of light elements.

Besides the chemical analysis at one spot on a sample (spot analysis) the micro-XRF is capable of performing one dimensional elemental profile analysis (line scans) as well as two dimensional elemental mapping. The step motor of the stage moves the sample under the stationary x-ray beam and the detector analyzes the fluorescence x-ray radiation. By moving the sample in equidistant steps a one or two dimensional matrix of spots can be analyzed. The evaluation software then calculates from the spectra of the matrix the spatial elemental distribution in form of line scans and elemental maps, respectively. This function is similar to the one used in electron microprobes and SEM-EDX systems. The difference lies in the size of the scanned area, which is in the range 60 x 50 mm with a micro-XRF compared to maybe 2 x 2 mm with electron optical techniques. The method of micro-XRF is therefore an excellent complement to the SEM and microprobe for large scale analysis. Figures 2 and 3 show examples of a line scan and a large area elemental mapping.

Spot analysis usually takes only between 30 and 200 seconds (dependant on whether

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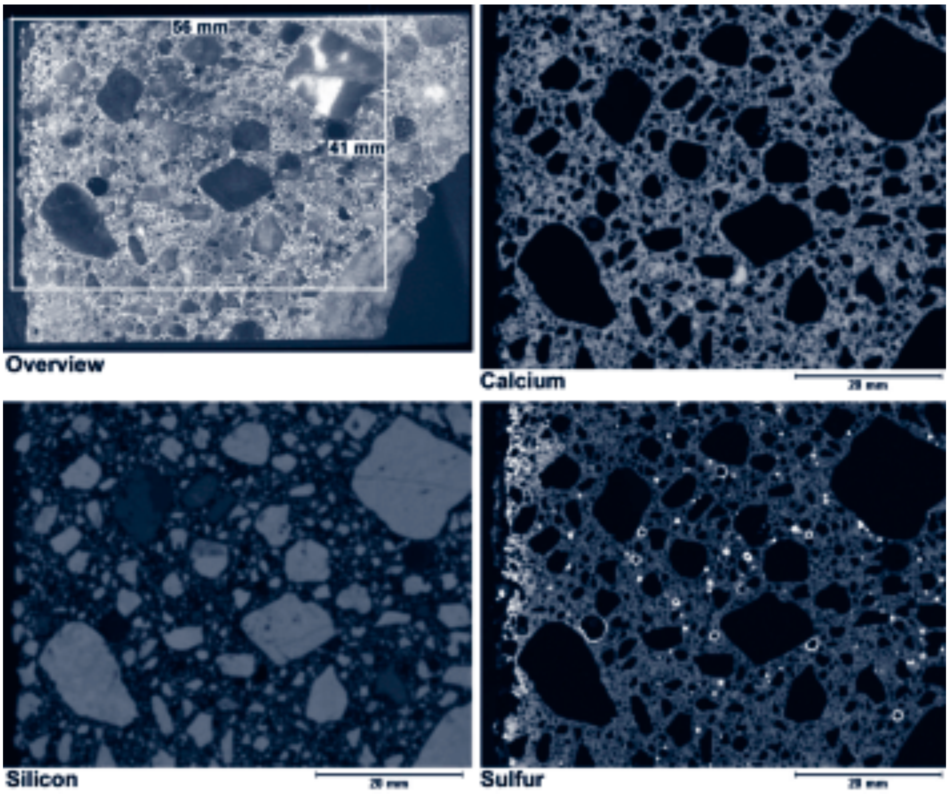

Figure 3. Concrete sample, which was affected by sulfate attack. The maps show the elemental distribution of calcium, silicon and sulfur. The sulfur map indicates an enrichment of sulfate in the first centimetres and on the walls of air voids.

qualitative or quantitative measurements are being carried out). However, line scans and elemental maps can take from a few minutes to more than ten hours depending on the resolution of the scan. For example, the acquisition of an elemental map of 256 x 200 spots takes around 4 hours. Higher resolution mappings take more time. The drawback of a long acquisition time for elemental maps, however, is compensated by a fully automated measurement mode and software evaluation. Therefore it is possible to measure high resolution scans without the need to communicate with the system during the run.

An analysis can be performed with different sample qualities. A spot analysis can be carried out with just a broken surface. Line scans and elemental maps can be performed even on cut surfaces. The tedious sample preparation of grinding and polishing known from SEM or microprobe techniques do not apply necessarily because of the large spot size. However, experience shows, that with an increase in surface quality the quality of the elemental maps increases. The technique of micro-XRF is particularly valuable for the micro structural and micro chemical analysis of building materials. A variety of problems can be approached with this method – from the simple analysis of the chemical composition of a cement powder to the visualization of the spatial distribution of a specific element in a concrete or brick sample. It is therefore most useful in the analysis of sample profiles, eg from a damaged sample surface to its undamaged interior. Due to the large size of the analyzed area, information about the elemental distribution, which was not possible before, can be obtained. The method is most efficient for this task when used in conjunction with optical microscopy where optical and textural data can be combined with the chemical information of a material.

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www.rabygg.is

Romania
INCERC – National Institute for Building Research
Institutul National de Cercetare în Constructii
www.incerc.ro

Italy
ITC – Istituto per le Tecnologie della Costruzione
Construction Technologies Institute www.itc.cnr.it

Poland
ITB – Instytut Techniki Budowlanej The Building Research Institute www.itb.pl

Portugal
LNEC – Laboratório Nacional de Engenharia Civil
www.lnec.pt

Sweden
SP – Swedish National Testing and Research Institute
www.sp.se

Netherlands
TNO – Building and Construction Research
www.bouw.tno.nl

Czech Republic
TZUS – Technical and Test Institute for Constructions Prague
www.tzus.cz

Slovakia
TSUS – Building Testing and Research Institute
www.tsus.sk

Finland
VTT – Building and Transport www.vtt.fi/rte

Slovenia
ZAG – Zavod za Gradbenistvo Slovenije Slovenian National Building and Civil Engineering Institute www.zag.si

in brief

CIB 2005 – Combining forces – Advancing facilities management and construction through Innovation

The CIB 2005 conference will be an important event presenting innovation in the real estate and construction sector. The objective of the conference will be to put construction management and economics into a perspective of modern real estate and construction activity. The potential advantages of implementing the results of completed research will be demonstrated together with the current and future needs of companies and society including refurbishment needs of post war housing in Europe, new megaprojects around the world, opportunities arising from e-business and telecommunication industries. CIB 2005 will take place in Helsinki between 13th and 16th June 2005. For more information see **www.ril.fi/cib2005**

The E-CORE B4E Conference

The date of the major E-CORE conference 'Building for a European Future – B4E' draws closer. The event, to be held in Maastricht between October 14th and 15th, is aimed at defining the crucial steps needed over the coming decade to create an innovative, competitive and successful industry. During the Conference, the goals and objectives for the construction industry and the research community will be debated.

To register and find our more about the conference see the special website at **http://www.b4e.org/homepage.cfm**

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Natural Ventilation Air Change Rates Considering Atmospheric Turbulence

– Estimates and measurements

When designing a naturally ventilated building an accurate estimate of air flows is essential to ensure enough air changes. In order to estimate air change rates (ACH) in a Natural Ventilation (NV) process common practice is to refer to the local average wind velocity. Local pressure coefficients (CP) allow this to be converted to ventilation driving pressures. This is a very simplified wind velocity model with clear limitations to cope with reality, when significant turbulence intensities are present, that may induce changes in wind velocities resulting in changes in local pressures and may reverse the flow through openings (Figure 1 overleaf).

A possible solution is to deal with a representative turbulent wind velocity time series (WTS) that may be obtained from the spectral representation of the wind turbulence spectrum. The main goal is then to obtain a stochastic process outcome (such as a wind velocity fluctuations time series) from its characteristic Power Spectral Density function (PSD).

The adopted wind model is based on the following conditions for the spectral micrometeorological range:

- Atmospheric turbulence is assumed to be an homogeneous and steady process, for average wind velocities above ~3 m/s
- Eddies' higher frequencies are isotropic
- Taylor's hypothesis of 'frozen turbulence' is valid, meaning that properties are kept and carried by the mean flow
- Kolmogoroff's postulate is valid (the energy cascade is present)
- A Gaussian distribution is assumed for one dimensional turbulence.

The adopted PSD function was proposed by Kaimal because it has the advantage of taking into account the height from ground.

After a reference wind time series is obtained, a set of time and space correlated series is needed to act upon each of the openings through which ventilation occurs. Cut-in frequencies depend on the building's overall dimensions and cut-off frequencies depend on opening dimensions. The integral scales are dependent on the atmospheric boundary layer (ABL) wind profile, terrain roughness and the building's overall dimensions.

For façades under separated flow it was assumed that the WTS reaching those openings was the reference one (or a correlated series) delayed by the time necessary for the mean wind velocity to carry it from the front façade (Figure 2 overleaf).

An estimate of an NV process for a building with a number of internal spaces depends on the knowledge of the flow velocity through each opening, a function of pressure, temperature and density variation in each one of the spaces. VENTIL (LNEC developed software package) assembles a set of non linear equations which allows it to be achieved, specifically:

- A mass, momentum (Bernoulli eq.) and energy balance equation for each opening
- An overall mass balance equation. In addition flow velocities 'seen' from both sides of any opening between adjacent spaces must cancel
- The perfect gas law.

VENTIL's present version runs a time step mode considering, any opening's own outside velocity evaluated from the described procedure.

Comparison between WTS and measured pressure spectrum shows that the spectral intensity of wind turbulence is over-evaluated for smaller frequencies ($n<0.02$ Hz) because the pressure slope should be twice that of the velocity slope (Figure 4 overleaf). Urban turbulence spectrum should be evaluated through specific measurements.

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Natural Ventilation Air Change Rates Considering Atmospheric Turbulence

– Graphics

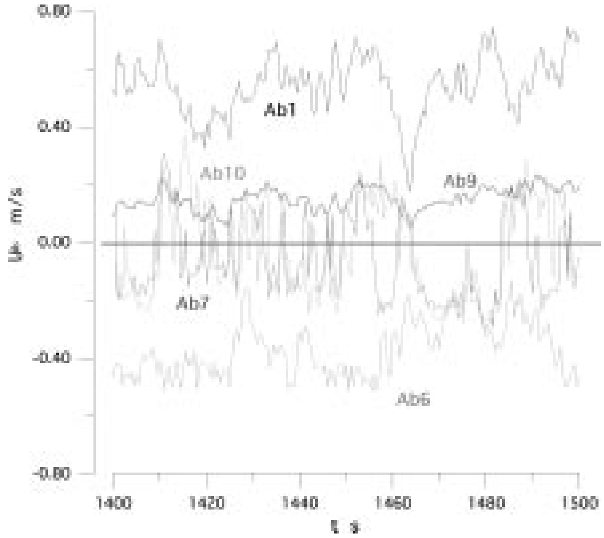

Figure 1 – Estimated WTS through openings

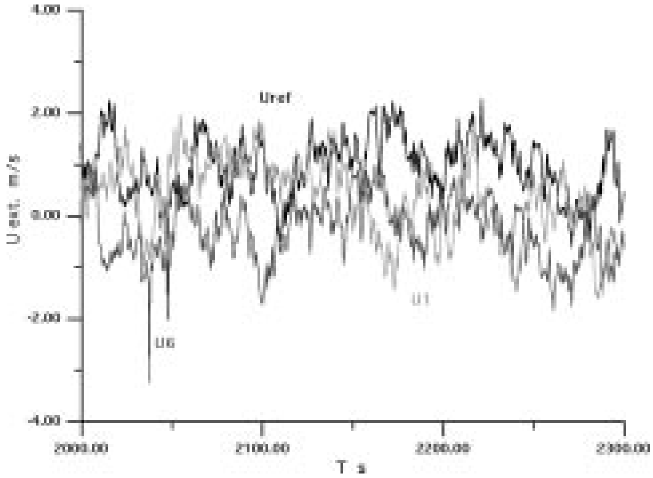

Figure 2 – Reference and two correlated synthetic WTS

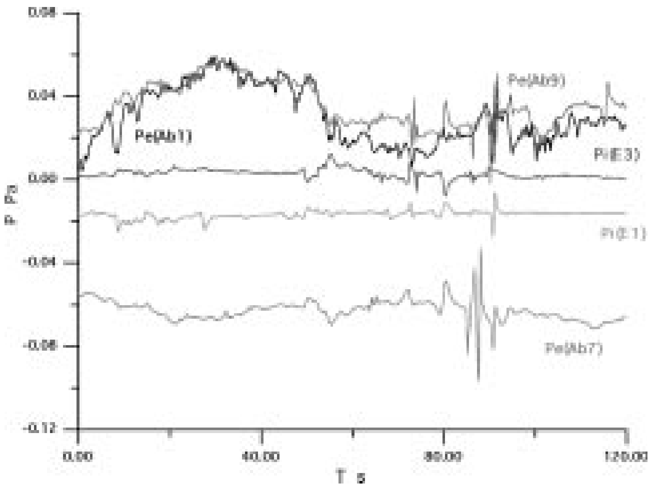

Figure 3 - Measured external and internal pressures

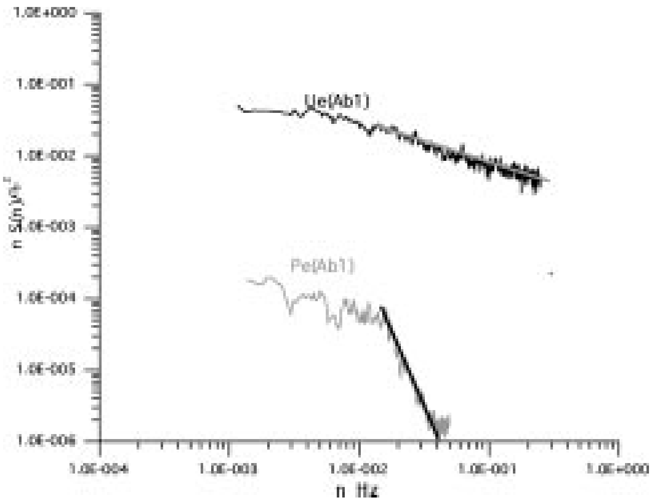

Figure 4 – Comparison between WTS and measured pressure spectrum

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